TEMPORAL TRENDS AND SPATIAL DISTRIBUTION OF ORGANOCHLORINE AND MERCURY RESIDUES IN GREAT LAKES SPOTTAIL SHINERS (1975 - 1983)

DECEMBER, 1985

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223.3
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Ontario
Ministry of the Environment

The Honourable
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Minister

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Deputy Minister

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December, 1985

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SUMMARY

Young-of-the-year spottail shiners (Notropis hudsonius) were used as biomonitors to assess temporal trends and the spatial distribution of organochlorine and mercury residues in the nearshore waters of the Great Lakes.

Survey results from ten selected sites on the lower Great Lakes show that recent PCB and total DDT residues have declined significantly ($p<0.01$) since the initial spottail shiner collections in the mid-1970's. PCB residue reductions over the entire study period (1975-1983) averaged 84 ng/g/yr, whereas residue declines during the eighties (1979-1983) averaged 28 ng/g/yr.

Residue reductions for total DDT for the same sampling intervals were 17 ng/g/yr and 7 ng/g/yr respectively. These observed changes in PCB and total DDT residues demonstrate decreasing residue reductions in the more recent spottail shiner collections.

Although mirex trends were not quantifiable, mirex residues in recent spottail shiner collections were generally lower than those of the mid-1970's.

Mercury and total chlordane residues have also declined significantly ($p<0.01$) in spottail shiners at most sites sampled.

Although PCB, total DDT, chlordane, mirex and mercury residues have declined, PCB and mirex accumulations in recent (1982/83) spottail shiner collections still exceeded the IJC Aquatic Life Guidelines at 54% and 23% respectively of the Great Lakes sites sampled. Generally the open lake responses, represented by adult salmonid and walleye data, were similar to the temporal contaminant trends observed in nearshore spottail shiners.

Elevated octachlorostyrene (560 ng/g) and hexachlorobenzene (231 ng/g) residues were found in the 1983 spottail collections from the St. Clair River. Trichlorotoluene was present at Cayuga Creek (22

ng/g) and Search and Rescue Stn. (35 ng/g) in the Niagara River. Chlorinated phenols were generally not detected in the spottail shiner collections from the Great Lakes.

Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) residues were not detected in the 1983 spottail shiner collections from the Niagara River and parts of western Lake Ontario. However, high concentrations of polychlorinated dibenzofuran (PCDF) residues were found at Wheatfield, N.Y. (3179 pg/g), Twelve Mile Creek (2150 pg/g) and the Humber River (1458 pg/g). The spatial distribution of dibenzofuran residues suggests that site-specific inputs govern dibenzofuran accumulation in nearshore fishes.

Heptachlor, aldrin, BHC, heptachlor epoxide, thiodan, dieldrin and endrin residues in spottail shiners were generally low and near the detection limits.

INTRODUCTION

A Nearshore Juvenile Fish Contaminants Surveillance Program was initiated by the Ontario Ministry of the Environment in 1975 to identify areas of concern for organochlorine contaminants in the Great Lakes. Surveillance data for a four year interval (1975-1979) were published in 1981 (Suns et al. 1981).

Young-of-the-year spottail shiners (Notropis hudsonius) have proven to be sensitive biomonitors for organochlorines and metals. Accumulated residues of these substances reflect the most recent water quality conditions and bioavailability of contaminants for a given locality. Due to their restricted nearshore habitat, young-of-the-year spottail shiners have useful applications in compliance monitoring and the detection of recently introduced persistent contaminants from land-based sources. As an early warning system, spottail shiner surveillance can identify emerging problems well before open lake responses become apparent.

The intent of this report is to update temporal trend data for organochlorine and mercury residues in spottail shiners and show the recent (1982/83) spatial distribution of contaminants in the nearshore waters of the Great Lakes in Ontario.

METHODS

Spottail shiner collection sites are identified in Figure 1 and Appendix 1. Fish were collected from nearshore waters using a 0.6cm mesh bagseine. In order to reduce the effects of seasonality, collections were timed to coincide with previous years' collections. Fish collections for Lake Superior were completed during late August, while most of the collections for the lower Great Lakes were done during September. Individual fish were measured (T.L.) and wrapped as ten fish composites in hexane-rinsed aluminum foil. Samples were stored at -20^{o}C for about three to four months before analyses.

Composites of 20 fish were used for all the TCDD and PCDF analyses, and composites of 10 fish for other contaminant residue determinations. Whole fish homogenates of each sample were analysed for contaminant residues and lipid contents. All analytical results were reported on a wet-weight basis.

Contaminant residues were identified and quantified at the Ontario Ministry of the Environment Laboratory in Rexdale. Packed column gas chromatography was used for PCB, HCB, heptachlor, mirex, aldrin, octachlorostyrene and p,p'DDE analyses. Capillary gas chromatography was used for chlordane, BHC, o,p'DDT and p,p'DDT residues. Simultaneous, dual capillary methods were used for chlorobenzene and chlorophenol residue determination. Total mercury residues were determined by standard cold vapour flameless atomic absorption. High resolution gas chromatography - low resolution mass spectrometry methods were used for all tetrachlorodibenzo - p-dioxin (2,3,7,8-TCDD) and polychlorinated dibenzofuran (PCDF) analyses. Further details of the analytical methods can be obtained from the Handbook of Analytical Methods for Environmental Samples, Laboratory Services Branch, Ontario Ministry of the Environment (1981).

Statistical significance was determined by t-tests for all spatial and temporal comparisons.

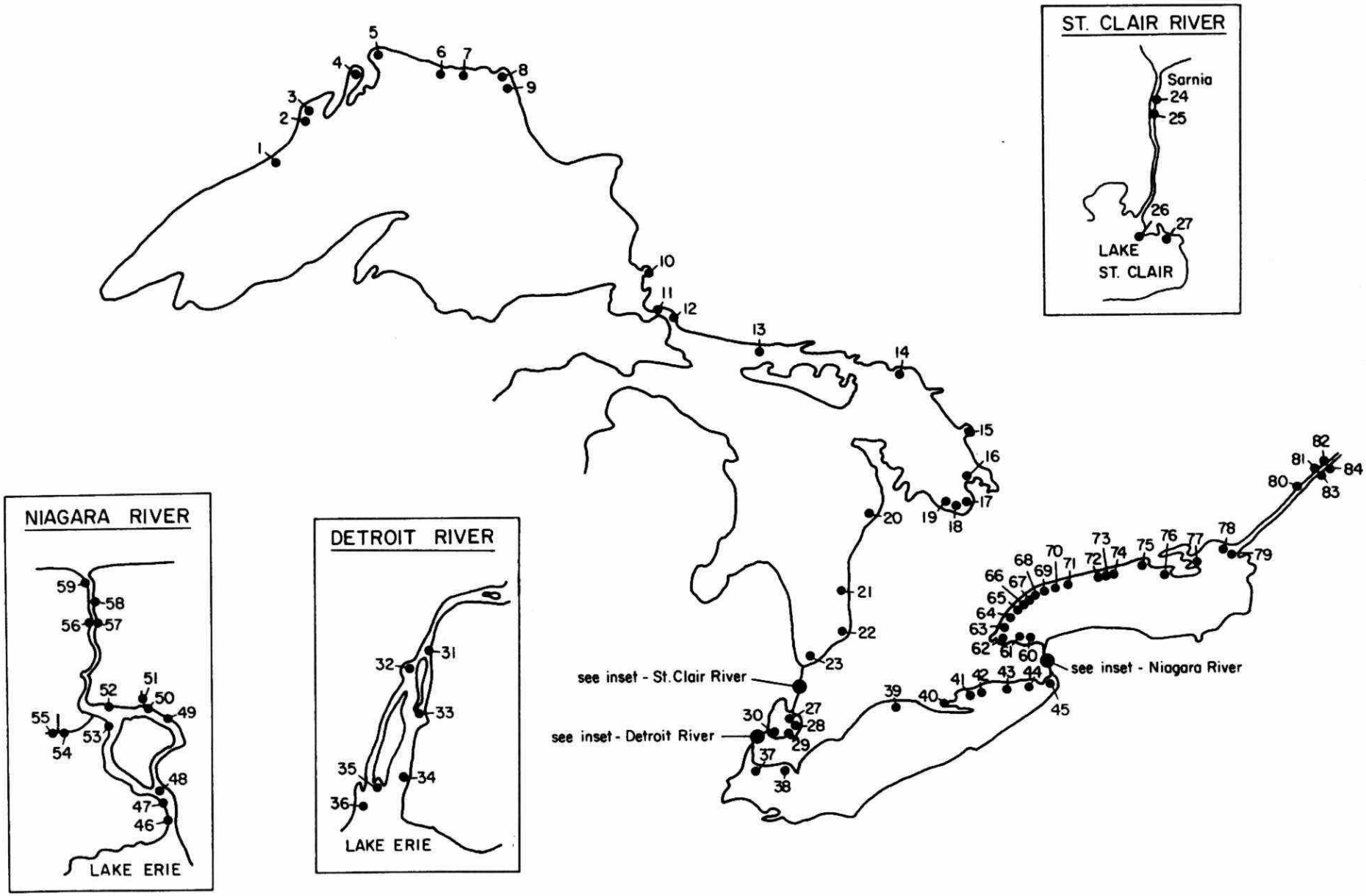

FIGURE 1. Spottail shiner collection sites on the Great Lakes.

RESULTS AND DISCUSSION

Since contaminant trend assessments in this report are based on collection sites where a minimum of four annual residue determinations have been made, temporal trend observations are limited to the responses of the lower Great Lakes only. The available spottail shiner data for the upper Great Lakes at present are too limited for trend evaluations.

PCBs

While recent (1982/83) PCB residue levels in young-of-the-year spottail shiners from the Great Lakes were significantly ($p<0.01$) lower than comparable residue accumulations of the mid-1970's, the downward trends identified in the earlier collections have moderated considerably in the 1980's (Appendix 2).

While PCB residue reductions for the entire study period (1975-1983) averaged 84 ng/g/yr, residue declines during the 1980's (1979-1983) averaged only 28 ng/g/yr (Table 1). Of the ten sites shown in Figure 2, only Pike Creek, Big Creek, Grand River and the Humber River collections continued to show residue declines in the 1980's (Table 1). PCB residue levels in spottail shiners during a four year interval (1979-1983) have changed little at Leamington, Thunder Bay, Niagara-on-the-Lake, Twelve Mile Creek and Cornwall.

Significant ($p<0.05$) PCB residue increases were noted in the 1982/83 spottail shiner collections at Port Stanley, Burlington Beach, Credit River and 102nd Street in Niagara Falls, N.Y. when compared to residue levels in previous collections. The latter site is associated with the former chemical disposal site at Love Canal. Although these residue increases are statistically significant, at this time they have to be viewed merely as fluctuations in terms of temporal trends because less than 4 years of data are available. Reasons for such fluctuations are not understood, although a number of biotic and abiotic factors may influence PCB residue bioavailability and its ultimate accumulation in fishes. An attempt is currently being made to assess the role of particle flux and variations in growth rates on PCB uptake in spottail shiners.

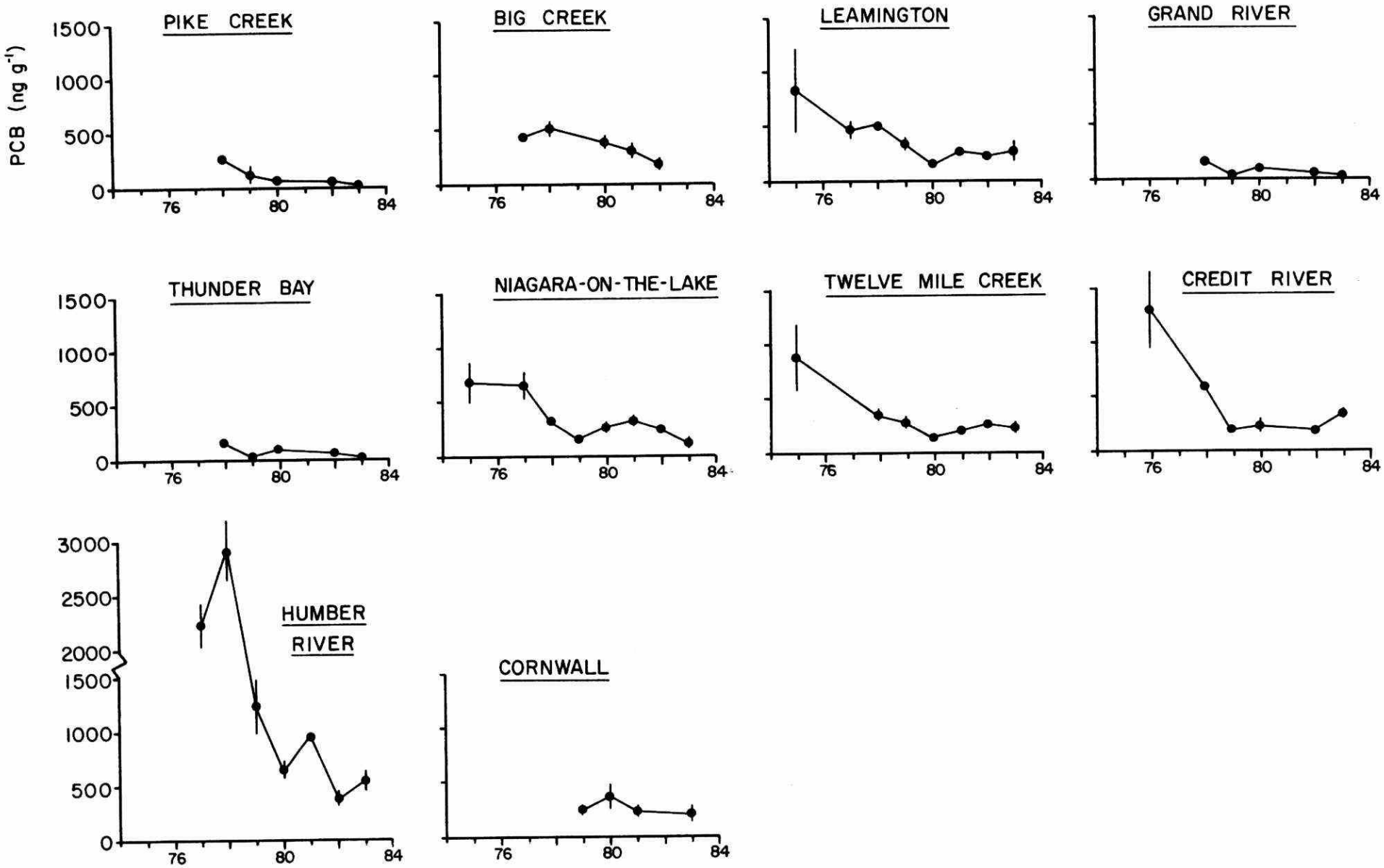

FIGURE 2. PCB residue trends in young-of-the-year spottail shiners. Values are means of composite samples with 95% confidence limits.

TABLE 1

Comparison of Long-Term (1975-1983) and Recent (1979-1983) Rates of Change of PCB and DDT Residues in Young-of-the-Year Spottail Shiners from the Lower Great Lakes.

SAMPLING SITE	INTERVAL SAMPLED	RESIDUE REDUCTION ng/g/yr PCB	≤DDT	INTERVAL SAMPLED	RESIDUE REDUCTION ng/g/yr PCB	≤DDT
Lake St. Clair						
Pike Creek	78-83	48	1	79-83	21	9
Lake Erie						
Big Creek	77-82	54	15	80-82	95	13
Leamington	75-83	73	10	79-83	19 N.S	3
Grand River	76-82	16	6	79-82	14	6
Thunder Bay	78-83	25	8	79-83	0	4
Niagara River						
Niagara-On-The-Lake	75-83	69	31	79-83	4 N.S	7
Lake Ontario						
Twelve Mile Creek	75-83	82	6	79-83	9 N.S	5
Credit River	76-83	141	36	79-83	35*	12
Humber River	77-83	280	37	79-83	172	7
St. Lawrence River						
Cornwall	79-83	11 N.S	9	79-83	11 N.S	9
All Sites						
Mean	75-83	84	17	79-83	28	7
Median	75-83	54-69	9-10	79-83	11-14	7

N.S - Not significant statistically ($p > 0.05$)
* - Denotes Residue Increase

PCB residue data from other sources dealing with open lake responses show that PCB residue trends (1979-83) are absent in channel catfish and walleye from western Lake Erie (A. Johnson, MOE, pers. comm; Report on Great Lakes Water Quality 1983). The absence of any significant PCB residue reductions in channel catfish and walleye may be indicative of continuing PCB inputs from the Detroit River, particularly from its west (Michigan) bank. The spottail shiner data show that PCB residue levels are 5-10 times higher in fish from the west bank collection sites (Appendix 2).

PCB residues in adult lake trout (4+), as well as in herring gull eggs from Lake Ontario have declined from 1977 - 1981, but have increased in 1982 (Report on Great Lakes Water Quality, 1983). Residues in rainbow trout from the Ganaraska R. collection show a continuing decline from 1976 through 1984 (A. Johnson, MOE, pers. comm.).

In spite of the fact that PCB residue data in adult sportfish, herring gull eggs and spottail shiners represent different components of the lake systems, the trend data for the nearshore and open lake responses are in general agreement. However, considering that spottail shiners are important forage fishes in the Great Lakes (Scott and Crossman 1973), it is not surprising to see the nearshore contaminant trends reflected in the higher trophic levels of the biota.

Efforts were made by all jurisdictions bordering on the Great Lakes to discontinue the open-ended uses of PCBs in the early 1970's, and the observed residue reductions may be attributed to the control measures implemented. It is evident that government controls of open-ended uses of PCBs were followed by substantial PCB residue reductions at various trophic levels, in spite of the presence of contaminated sediments. The present state of PCB residue trends suggest that additional control or clean-up efforts may be required to restrict residual and secondary sources of PCB inputs in order to further reduce residue levels in the biota of the Great Lakes. Aspects of PCB remobilization from sediments are currently under investigation.

Based on collections in 1979 and 1983, PCB residues have also increased in young-of-the-year spottail shiners at four Lake Superior sites during this four year interval (Appendix 2). Further collections in 1984 and 1985 are planned to assess the significance of the observed increases. PCB residues in the edible portions of sportfish from Lake Superior have declined from 1978 through 1983 (A. Johnson, MOE, pers. comm.) PCB residues in samples of herring gull eggs from Lake Superior have also declined from 1974-1981 (Report on Great Lakes Water Quality 1983).

Of the fifty-six Great Lakes sites sampled in 1982/83, PCB residue levels in spottail shiners at thirty sites (54%) were in excess of the IJC Aquatic Life Guideline of 100ng/g. Table 2 provides an overview of the average regional PCB values and sites exceeding IJC Guidelines in Ontario and U.S. waters. The lowest PCB residues were found in spottail shiner collections from Lake St. Clair and eastern Lake Erie, while higher PCB residue levels were found in the Detroit River, western Lake Erie and western Lake Ontario. Particularly high residue accumulations were present in collections from the U.S. shoreline in Detroit River, Niagara River and the St. Lawrence River. Generally the highest PCB residues were found at sites with high industrial development, whereas collections from rural areas of eastern Lake Erie and eastern Lake Ontario had considerably lower PCB residues.

DDT and Metabolites

Total DDT residues in the Great Lakes spottail shiners have declined substantially during the late 1970's (1976-1979) and all recent (1982/83) levels are significantly ($p<0.01$) lower than comparable values in the initial surveys. Since total DDT reductions in spottail shiners followed the province-wide ban of DDT in the early 1970's, it may be concluded that use restrictions have reduced DDT inputs to the Great Lakes. Total DDT residue declines ranged from 1 ng/g/yr to 37 ng/g/yr (Table 1). Total DDT residues have continued to decline during the 1980's at slightly reduced rates, and a number of residue levels in recent collections are

TABLE 2

Regional Means of PCB Residues in Young-of-the-Year Spottail Shiners from Recent (1982/83) Collections

	ONTARIO WATERS			U.S. WATERS		
	NO. OF SITES SAMPLED	MEAN PCB RESIDUES ng/g	NO. OF SITES EXCEEDING IJC GUIDELINE	NO. OF SITES SAMPLED	MEAN PCB RESIDUES ng/g	NO. OF SITES EXCEEDING IJC GUIDELINE
Lake Superior	9	65	2			
St. Clair River	3	81	1			
Lake St. Clair	4	38	0			
Detroit River	3	253	3	3	1873	3
Lake Erie West	3	227	3			
Lake Erie East	4	40	0			
Niagara River	7	116	3	7	366	6
Lake Ontario West	7	354	7			
Lake Ontario East	2	104	1			
St. Lawrence River	2	174	2	1	954	1

IJC guideline for protection of aquatic life - 100 ng/g

approaching the analytical detection limits (Appendix 2; Fig. 3). Total DDT residue data for adult fishes and herring gull eggs are generally in agreement with the nearshore trends for spottail shiners through 1979. (Report on Great Lakes Water Quality 1983; A. Johnson, MOE, pers. comm.). However, total DDT residues in spottail shiners continued to decline at most sites during the early 1980's, whereas increasing total DDT residue levels have been reported for herring gull eggs from Lake Erie and Lake Ontario (Report on Great Lakes Water Quality 1983).

Although total DDT residue fluctuations in spottail shiners remain largely unexplained, residue increases at Niagara-on-the-Lake in 1981 and 1982 were investigated and appeared to be related to agricultural run-off with high DDT content (Suns et al. 1983).

Total DDT residues in all recent (1982/83) spottail shiner collections were well below the IJC Aquatic Life Guideline of 1000 ng/g and DDT residues consisted largely of the metabolite DDE.

Mirex (Dechlorane)

Since mirex residues for most of the recent spottail shiner collections were near or below their detection limits, data could not be quantified with any confidence for trend assessment (Appendix 2). Trend evaluations were complicated by the extreme residue fluctuations observed at Niagara-on-the-Lake and Twelve Mile Creek. Nevertheless, mirex residues in spottail shiners have declined considerably when comparing values from recent collections with those of the initial surveys (Figure 4). Of particular interest are the mirex residue reductions in spottail shiner collections from the Niagara River at Niagara-on-the-Lake. The noted mirex residue declines in the Niagara River may be associated with the discontinuation of mirex packaging operations at Niagara Falls, N.Y. during the mid-1970's. Since the Niagara River is considered to be a major source of mirex to Lake Ontario, (Environment Canada 1977, Pickett and Dossett 1979), the noted residue reductions suggest that mirex inputs to Lake Ontario have declined . These findings are in

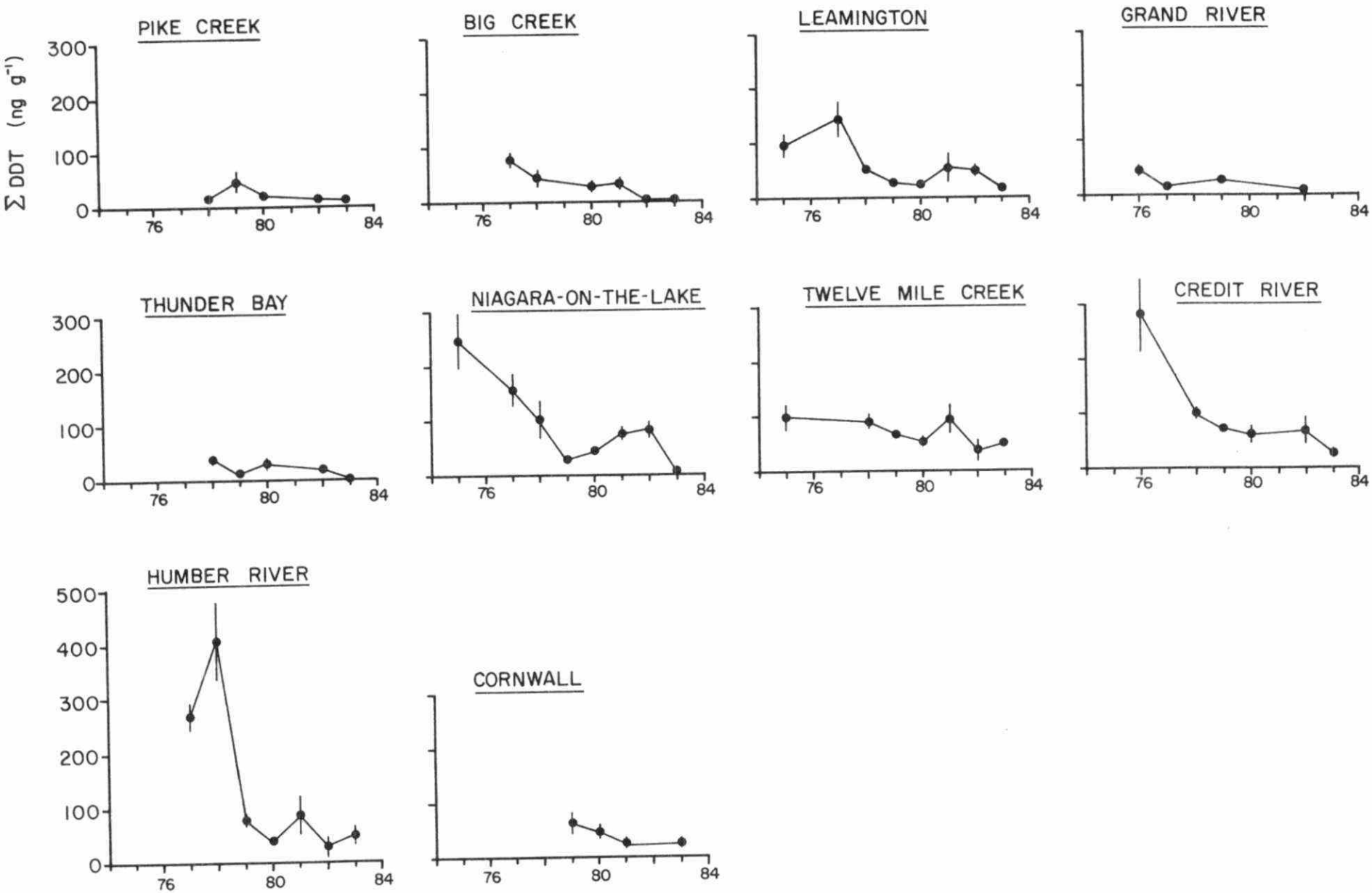

FIGURE 3. ΣDDT residue trends in young-of-the-year spottail shiners. Values are means of composite samples with 95% confidence limits.

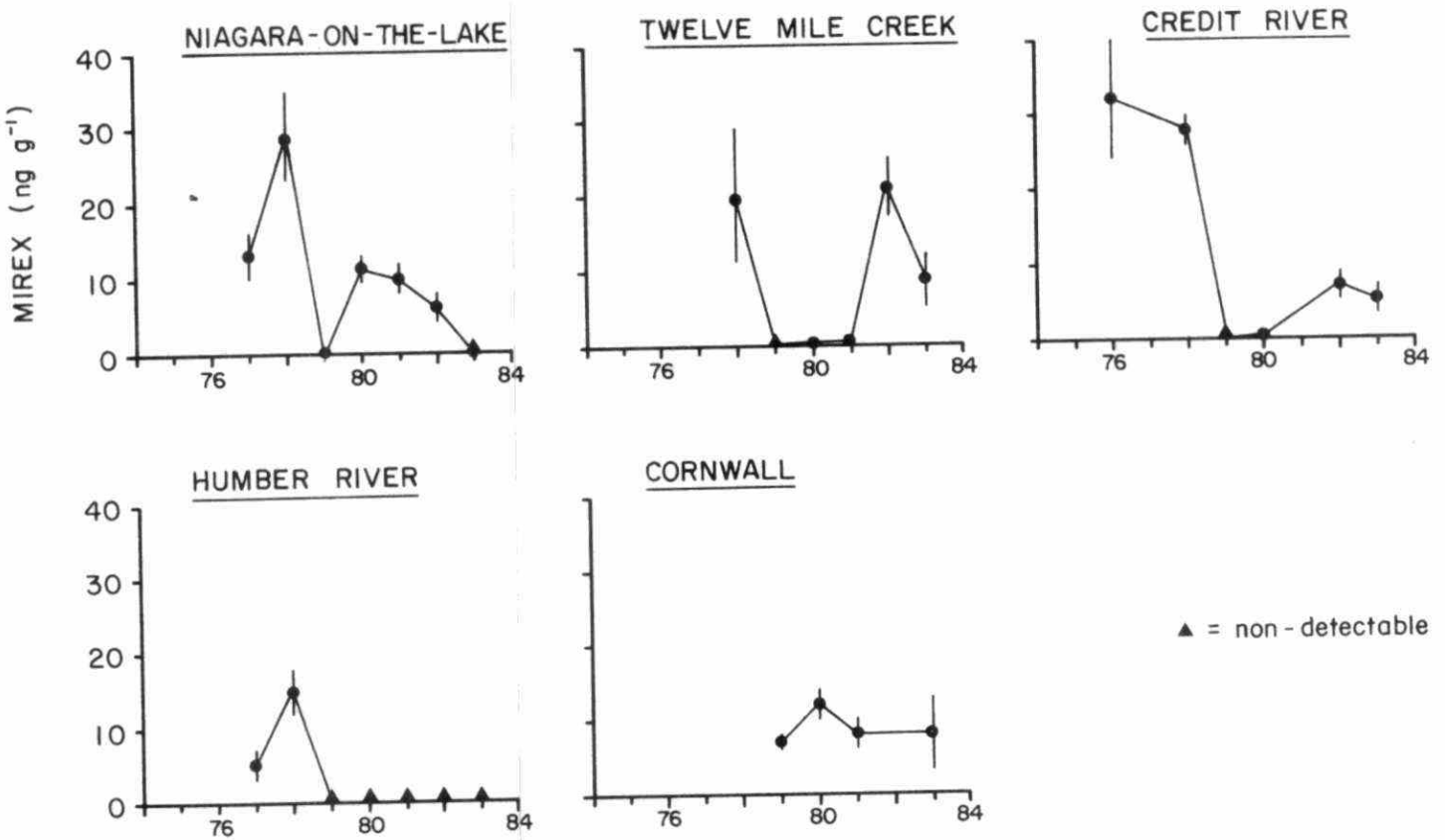

FIGURE 4. Mirex residue trends in young-of-the-year spottail shiners. Values are means of composite samples with 95% confidence limits.

agreement with the observed mirex residue trends for Lake Ontario lake trout (4+), rainbow smelt and herring gull eggs, except that herring gull egg residues have increased in 1981 (Report on Great Lakes Water Quality 1983).

Mirex residues have changed little in spottail shiner collections from the St. Lawrence River at Cornwall throughout the sampling interval 1979-1983 (Figure 4). Since mirex was not-detected at either Lawrence River sites upstream from Cornwall (Appendix 2), the residues found in the Cornwall collections were possibly of local unknown origin and not residuals from Lake Ontario. Trace levels of mirex, within acceptable levels for unrestricted consumption, occur in sportfish throughout the St. Lawrence. While sources of mirex in the St. Lawrence remain undefined, inputs from Oswego, N.Y. might have contributed.

Mirex residues were detected only in parts of Niagara River, Lake Ontario and the St. Lawrence River, and residue levels were found to be above the Aquatic Life Guideline (Great Lakes Water Quality Agreement 1978) at 8 of the 18 sites sampled in 1982/83. The Aquatic Life Guideline requires mirex to be "substantially absent" in the biota.

Mercury

Mercury residues in spottail shiners have declined significantly ($p<0.01$) at five of the seven sites where trend data are available (Figure 5). Details of the mercury data are shown in Appendix 3. Mercury concentrations in spottail shiners have remained virtually unchanged for a four year interval (1978-1982) at Pike Creek in Lake St. Clair and the Credit River in Lake Ontario. While considerable residue declines have occurred at Big Creek, Leamington, Grand River and the Niagara-on-the-Lake collection sites, recent mercury residue values indicate a levelling-off of the residue declines.

Generally, the open lake responses, represented by adult sport fish data, support the observed mercury residue trends in spottail shiners. Mercury in adult northern pike and walleye from Lake St. Clair continues to decline, although at reduced rates during the

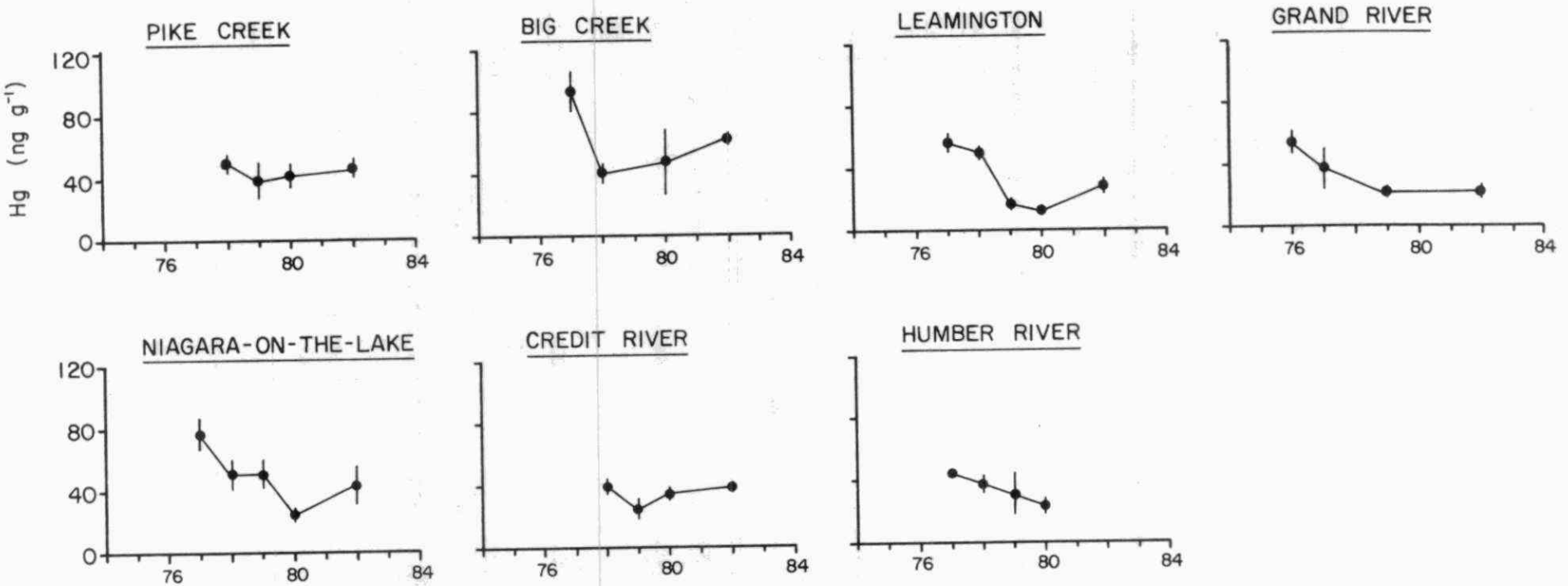

FIGURE 5. Mercury residue trends in young-of-the-year spottail shiners. Values are means of composite samples with 95% confidence limits.

early 1980's (A. Johnson, MOE, pers. comm.). Similarly, mercury declines have slowed in recent collections of Lake Erie walleye and Lake Ontario lake trout (4+) when compared to rates of change in earlier fish samples. (Report on Great Lakes Water Quality, 1983).

The highest mercury residues were found in spottail shiners from the 102nd Street collection site in Niagara Falls, N.Y. Mercury residues in these collections were clearly elevated and may be indicative of mercury inputs from the chemical disposal site at Love Canal. Mercury residues have been identified in Love Canal landfill leachate (McDougal et al, 1980). Mercury residues in all the Great Lakes spottail shiner collections were found to be below the Aquatic Life Guideline of 500 ng/g (Great Lakes Water Quality Agreement 1978).

Chlorinated Aromatics

Chlorinated aromatic residue data for the Great Lakes spottail shiners are shown in Appendix 4. Since the data base is small, proper temporal trend assessment is not possible and data use will be restricted to identifying areas of concern.

Spatial distribution patterns of hexachlorobenzene and octachlorostyrene residues in recent (1982/83) spottail shiner collections identified elevated residue levels at Sarnia-3 site in the St. Clair River. Hexachlorobenzene residues of 231 ng/g at Sarnia-3 were well above the typical levels found in the Great Lakes spottail shiners, which usually range from not-detected to 10 ng/g. Likewise, octachlorostyrene accumulations of 560 ng/g in the Sarnia-3 spottail shiner collections exceeded the not-detected to 6 ng/g range commonly found at other Great Lakes sites. These elevated residues suggest active hexachlorobenzene and octachlorostyrene inputs to the St. Clair River. Results from sediment surveys in the St. Clair River support the spottail shiner residue distributions (Oliver and Burtonniere 1985). Elevated octachlorostyrene residues in the St. Clair River spottail shiners extend to the Chenal Ecarte (28 ng/g) and the South Channel (95 ng/g) estuaries in Lake St. Clair, whereas the impact of hexachlorobenzene appears to be more localized.

Elevated levels of trichlorotoluene and chlorobenzene residues were found in spottail shiner collections at Cayuga Creek, Niagara Falls, N.Y. Cayuga Creek receives drainage via a storm sewer from the former waste disposal site at Love Canal. These results may indicate residual seepage from the waste disposal site. Trichlorotoluene and chlorobenzenes have been identified in the leachate from the Love Canal landfill (McDougall et al, 1980; Elder et al. 1981). In contrast to the frequent presence of low-level chlorinated aromatics in spottail shiners from the lower Great Lakes, chlorinated aromatics were not detected in any spottail shiner collections from Lake Superior.

Chlorinated Phenols (PCPs)

Trichlorophenol and tetrachlorophenol residues were not detected in any of the recent (1982/83) spottail shiner collections from the Great Lakes, whereas pentachlorophenol was present in the 102nd Street collections (70 ng/g) in Niagara Falls, N.Y. (Appendix 5). While pentachlorophenol is bioaccumulative, produced and used in large quantities in Canada and the U.S. (Fox and Joshi 1984), the low residue values found have to be attributed to its short residence time in aquatic systems (Niimi and Cho 1983).

The highest pentachlorophenol accumulations in spottail shiners were noted in the 1981 collections from Mimico Creek (1467 ng/g). These residue levels were much above the typical pentachlorophenol concentrations seen elsewhere in the Great Lakes spottail shiners (Appendix 5), and possibly related to a spill, although there is no documentation to support this. However, the pentachlorophenol residue decline in Mimico Creek spottail shiners has been rapid and in 1983 PCP residues were no longer detected.

Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD)

Dioxin (2,3,7,8-TCDD) residue data for spottail shiners are limited to collections from the Niagara River and western Lake Ontario (Table 3). Spottail shiner collections in 1981 identified active 2,3,7,8-TCDD inputs from Love Canal via Cayuga Creek to the Niagara River. Elevated residue levels of 2,3,7,8-TCDD have been identified

TABLE 3

Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) Residues in Young-of-the-Year Spottail Shiners from Selected Sites in the Niagara River and Lake Ontario.

		2,3,7,8-TCDD					
SITE		1981		1982		1983	
NO.	SAMPLING SITE	N	pg/g	N	pg/g	N	pg/g
46	Fort Erie			1	ND		
47	Frenchman's Creek	1	15	1	ND		
49	Wheatfield, N.Y.					1	ND
50	102nd St. Niagara Falls, N.Y.	2	8				
51	Cayuga Creek, N.Y.	2	59				
52	Search & Rescue Stn., N.Y.			1	ND	1	ND
53	Usher's Creek			1	ND	1	ND
58	Peggy's Eddy, N.Y.	2	7				
59	Niagara-On-The-Lake	2	14			1	ND
61	12 Mile Creek					1	ND
62	Burlington Beach					1	ND
66	Humber River					1	ND

Detection Limit - 3 pg/g
ND - Non Detectable
N* - Number of Samples, Each Sample is a composite of 20 Fish

in sediment samples from the Love Canal area (Smith et al, 1983). 2,3,7,8-TCDD residues in spottail shiners from various parts of the Niagara River were substantially lower than residues in the Cayuga collections. However, 2,3,7,8-TCDD concentrations above their detection limits were found in all the spottail shiner samples from the Niagara River in 1981. While the data base is small, 2,3,7,8-TCDD residues in all the 1982 and 1983 spottail shiners analyzed were below their detection limits. Of interest were the 2,3,7,8-TCDD residue declines at Frenchman's Creek and, particularly, at Niagara-on-the-Lake, where residue levels have decreased from an average value of 14 pg/g in 1981 to not detected levels in 1983.

Polychlorinated Dibenzofurans (PCDF)

Polychlorinated dibenzofuran residue data for spottail shiners are available from a few selected sites in Niagara River and western Lake Ontario (Table 4).

In general, PCDF residue accumulations in spottail shiners from the Niagara River and Lake Ontario were much higher than reported whole fish residues (12-290 pg/g) from the Great Lakes (Stalling et al. 1981). The highest PCDF levels were found in spottail shiner collections at Wheatfield (3179 pg/g) in North Tonawanda, N.Y. High residues were also found in the collections from Twelve Mile Creek (2150 pg/g) and the Humber River (1458 pg/g).

The observed spatial distribution pattern of PCDF residues in spottail shiners suggests that localized inputs of PCDFs play a major role in fish contamination in the nearshore waters. No relationships between PCB and PCDF residues in spottail shiners were apparent.

TABLE 4

Polychlorinated Dibenzofuran Residues in Young-of-the-Year Spottail Shiners from Selected Sites in Niagara River and Lake Ontario - 1983.

		CONGENER MIX % TO TOTAL					TOTAL
SAMPLING SITE	N	4Cl	5Cl	6Cl	7Cl	8Cl	PCDF-pg/g
Wheatfield, N.Y.	1	24	17	38	20	1	3179
Search & Rescue Stn., N.Y.	1	56	23	17	4	0	646
Usher's Creek	1	99	1	0	0	0	232
Niagara-On-The-Lake	1	57	19	16	8	0	680
12 Mile Creek	1	51	20	24	5	0	2150
Burlington Beach	1	100	0	0	0	0	472
Humber River	1	65	10	21	4	0	1458

Detection Limit - 3pg/g

N - Number of Samples - Each Sample is a composite of 20 fish

Stalling et al. (1981) report that the dominant portion of the PCDF residues in Great Lakes fishes were isomers with 2,3,7,8-chlorine substitutious. Although tetra congeners represented the major component of PCDF residues in spottail shiners, isomer data for spottail shiner residues at present are not available.

The significance of the PCDF accumulations in spottail shiners remains undetermined because their biological uptake and toxicological responses are both isomer-specific (Hallett et al. 1980). Since preferential accumulation or retention of the 2,3,7,8-substituted congeners has been documentated in the Great Lakes fishes, further residue characterization to the isomer level is necessary for spottail shiner data evaluation.

Total Chlordane

Total chlordane residues in recent (1982/83) spottail shiner collections were generally lower than residue levels in earlier samples. Significant ($p<0.01$) total chlordane residue reductions were noted at Pike Creek, Leamington, Grand River, Thunder Bay, Credit River and the Humber River (Figure 6; Appendix 2). The highest total chlordane residues were found in spottail shiners from the Niagara River and western Lake Ontario. With the exception of the Welland Canal, Mimico Creek and Humber River collections, total chlordane levels in recent (1982/83) spottail shiner collections were generally near the detection limits.

Other Pesticides

Residue levels for aldrin, dieldrin, endrin, thiodan, heptachlor, heptachlor epoxide and total BHC were generally low in all spottail shiner collections.

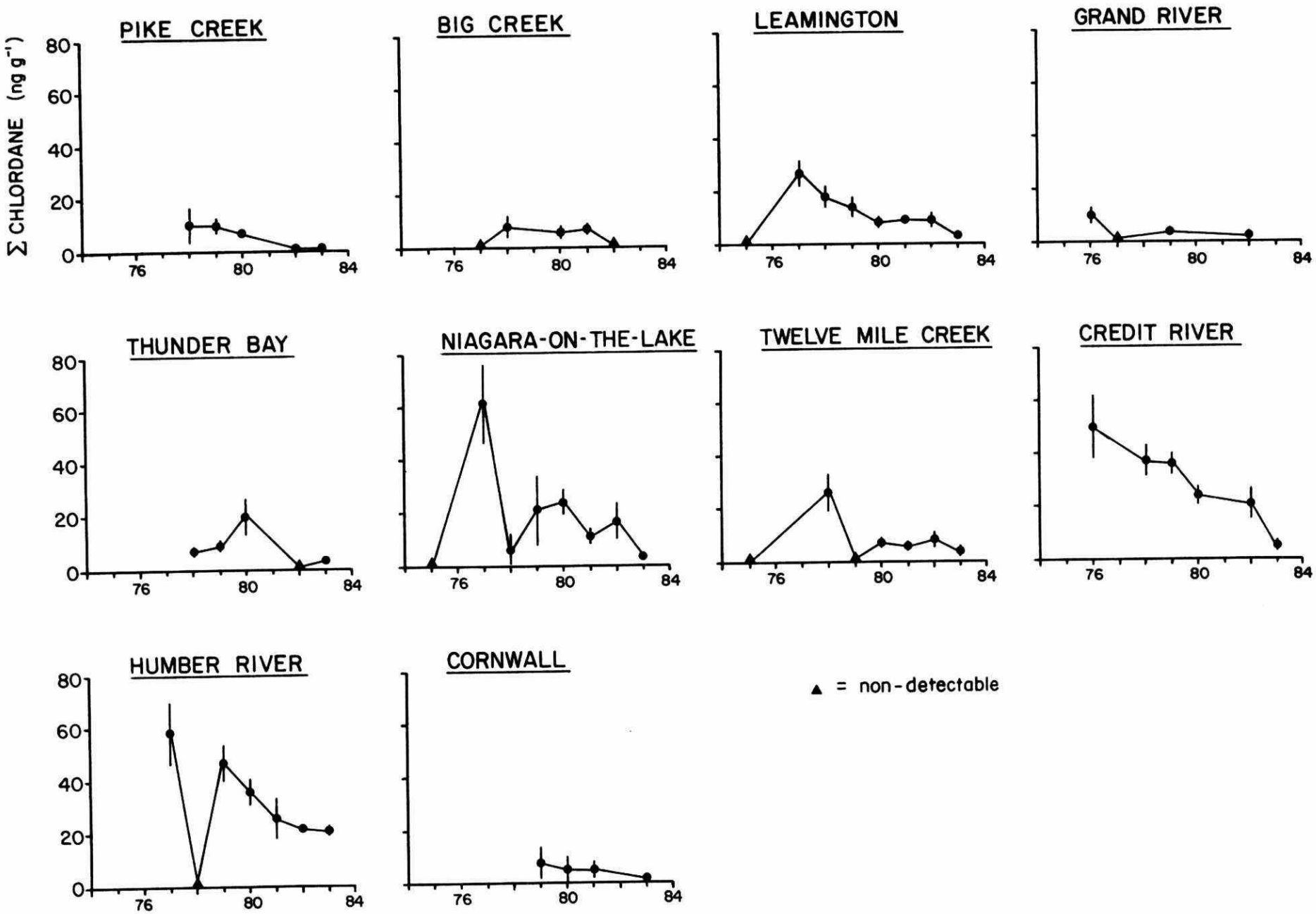

Figure 6. ΣChlordane residue trends in young-of-the-year spottail shiners. Values are means of composite samples with 95% confidence limits.

CONCLUSIONS

Since the implementation of restrictive use and discharge regulations for PCBs and DDT coincide with the noted resided declines in spottail shiners, it may be concluded that Government regulations have effectively reduced the input of these contaminants and their accumulation in the Great Lakes biota. While residue declines, particularly for PCBs, have moderated in the early 1980's, there is no evidence of constant residue increases that may lead to increasing PCB residue trends in the future. However, PCB residues in the 1982/83 spottail shiner collections exceeded the IJC Aquatic Life Guideline (100 ng/g) at 54% of the Great Lakes sites sampled. Additional clean-up efforts may be necessary to restrict residual and secondary PCB sources in order to further reduce PCB residues in the biota and meet IJC Guidelines at all locations on the Great Lakes.

Although temporal mirex trends in the Niagara River and Western Lake Ontario remain undefined due to the extreme residue fluctuations, residue levels in recent spottail shiner collections were clearly lower than residues in comparable samples from the mid-1970's. These mirex residue reductions may be indicative of reduced mirex inputs to the Niagara River due to the discontinuation of mirex packaging operations during the mid-1970's in Niagara Falls, N.Y. Mirex residues in spottail shiners exceeded the IJC Aquatic Life Guideline at 44% of the Niagara River, Lake Ontario and St. Lawrence River sites sampled.

While mercury residues in spottail shiners have decreased at several of the Great Lakes sites sampled, the reasons for mercury residue declines are not known.

Elevated octachlorostyrene and hexachlorobenzene residues were found in spottail shiners from the St. Clair River, indicating inputs to the River. Trichlorotoluene and chlorobenzene residue accumulations in spottail shiners from Cayuga Creek were high and suggested seepage from the Love Canal landfill. Generally, the occurrence and residue accumulations of chlorinated aromatics were low in most Great Lakes spottail shiners sampled.

The observed absence of detectable chlorophenol residues in spottail shiners and the rapid residue degradation at Mimico Creek suggest that chlorophenols have a short residence time in aquatic systems.

In contrast to the 2,3,7,8-TCDD residues, polychlorinated dibenzofuran residues were found in spottail shiners at all sites sampled. The spatial distribution patterns of PCDF residues in spottail shiners indicate that site-specific inputs govern PCDF accumulations in nearshore fishes. Since toxicological responses are isomer-specific, further residue characterization to the isomer level is necessary to assess the significance of PCDF residue concentrations.

Although the data base for tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) residues was too small for temporal trend assessment, it is noteworthy that 2,3,7,8-TCDD residues were not detected in any of the 1983 spottail shiner samples analysed from the Niagara River and parts of western Lake Ontario.

The observed total chlordane residue trends in spottail shiners indicate that chlordane inputs to the Great Lakes have declined. The higher total chlordane residues were generally found in spottail shiners from urbanised watersheds, probably as a result of domestic use of chlordane.

The evidence presented in this report shows that there was a correlation between the Government-imposed restrictions of PCB and DDT use and their accumulation in spottail shiners. Furthermore, the observed contaminant trends with time in nearshore spottail shiners were generally reflected at higher trophic levels in the Great Lakes biota as evidenced by contaminant trends in sportfish and herring gull eggs.

The noted linkage between reduced contaminant inputs and residue declines in the biota shows that the recovery potential of the Great Lakes biota is considerable. It is, therefore, essential to maintain and enforce proper use and discharge regulations of all persistant contaminants if further residue reductions in the biota are to be achieved.

ACKNOWLEDGEMENTS

We would like to thank Mr. G. Hitchin for the graphics. We gratefully acknowledge Dr. I. Heathcote and Mr. F. Fleischer for their valuable suggestions and Messrs. C. Schenk, J. G. Ralston, W. Scheider and A. Johnson for reviewing the manuscript.

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APPENDICES

APPENDIX 1

SITE IDENTIFICATION FOR SPOTTAIL SHINER COLLECTIONS

SITE NO.	SAMPLING SITE		
1	LAKE SUPERIOR	PINE BAY	PINE RIVER DELTA
2	" "	KAM RIVER	NORTH OF THE PIER
3	" "	MISSION RIVER	MISSION RIVER DELTA
4	" "	BLACK BAY	HARKETT COVE
5	" "	NIPIGON BAY	FIVE MILE POINT
6	" "	TERRACE BAY	EAST SHORE OF BAY
7	" "	JACKFISH BAY	EAST SHORE OF BAY
8	" "	HERON BAY	LITTLE BLACK RIVER
9	" "	PENINSULA HARBOUR	BEATTY COVE
10	" "	BATCHEWANA BAY	BATCHAWANA RIVER DELTA
11	ST. MARY'S RIVER	SAULT STE. MARIE	CITY PARK AT QUEEN ST.
12	" "	LITTLE LAKE GEORGE	GARDEN RIVER DELTA
13	GEORGIAN BAY	BLIND RIVER	NEW BLIND RIVER CHANNEL
14	" "	FRENCH RIVER	MAIN FRENCH R. DELTA
15	" "	SEGUIN RIVER	SEGUIN RIVER DELTA
16	" "	THUNDER BEACH	THUNDER BAY BEACH
17	" "	NOTTAWASAGA RIVER	NOTTAWASAGA R. DELTA
18	" "	PRETTY RIVER	PRETTY R. DELTA
19	" "	BEAVER RIVER	BEAVER R. DELTA
20	LAKE HURON	SAUGEEN RIVER	SAUGEEN R. DELTA
21	" "	MAITLAND RIVER	MAITLAND R. DELTA
22	" "	AUSABLE RIVER	S. SIDE OF HARBOUR
23	" "	PERCH CREEK	PERCH CK. AT BRIDGE
24	ST. CLAIR RIVER	SARNIA-3	DOWNSTREAM SUNCOR REF.
25	" "	STAG ISLAND	S.E. TIP OF ISLAND SHORE
26	" "	SOUTH CHANNEL	E. SHORE SEAWAY ISLAND
27	LAKE ST. CLAIR	CHENAL ECARTE	AT R. CURTIS COTTAGE
28	" "	MITCHELL BAY	N. OF MITCHELL BAY BEACH
29	" "	THAMES RIVER	N.E. SIDE OF THAMES DELTA
30	" "	PIKE CREEK	W. SIDE OF CREEK
31	DETROIT RIVER	TURKEY CREEK	CREEK/RIVER CONFLUENCE
32	" "	GRASSY ISLAND (MICH)	S.W. SHORELINE
33	" "	FIGHTING ISLAND	S.E. SHORELINE
34	" "	AMHERSTBURG	S. OF FERRY DOCK
35	" "	CELERON ISL.(MICH)	S. SHORELINE
36	" "	STURGEON BAR (MICH)	N.W. SHORELINE
37	LAKE ERIE	BIG CREEK	BEACH AT PROV. PARK
38	" "	LEAMINGTON(PT.PELEE)	BEACH EAST OF PIER
39	" "	PORT STANLEY	BEACH E. OF HARBOUR
40	" "	PORT ROWAN	EAST OF PIER
41	" "	CENTRE CREEK	BEACH W. OF CREEK
42	" "	NANTICOKE CREEK	BEACH E. OF CREEK
43	" "	GRAND RIVER	BEACH E. OF PIER
44	" "	PORT COLBORNE	W. OF WELLAND CANAL
45	" "	THUNDER BAY	BEACH AT BERNARD ST.

SITE NO.	SAMPLING SITE		
46	NIAGARA RIVER	FORT ERIE	BEACH DOWNSTREAM OF BRIDGE
47	" "	FRENCHMAN'S CK.	CREEK/RIVER CONFLUENCE
48	" "	STRAWBERRY ISL.(NY)	N.W. SHORELINE
49	" "	WHEATFIELD (NY)	WHEATFIELD OLD DOCK
50	" "	102ND ST., NIAGARA FALLS (NY)	LITTLE R. AT 102ND ST.
51	" "	CAYUGA CREEK(NY)	LITTLE R. AT CAYUGA
52	" "	SEARCH & RESCUE STN(NY)	N. OF BOAT BASIN
53	" "	USHER'S CREEK	CREEK/RIVER CONFLUENCE
54	" "	EAST WELLAND RIVER	E. OF POWER CANAL
55	" "	WEST WELLAND RIVER	W. OF POWER CANAL
56	" "	QUEENSTON	DOWNSTREAM 0.5km
57	" "	LEWISTON (NY)	OPPOSITE QUEENSTON
58	" "	PEGGY'S EDDY (NY)	DOWNSTREAM OF S.C.A.
59	" "	NIAGARA-ON-THE-LAKE	AT FORT GEORGE
60	LAKE ONTARIO	WELLAND CANAL	E. OF CANAL
61	" "	TWELVE MILE CK.	W. SIDE OF PIER
62	" "	BURLINGTON BEACH	N. OF CANAL
63	" "	BRONTE CREEK	E. OF PIER
64	" "	CREDIT RIVER	RICHARD MEMORIAL PARK
65	" "	MIMICO CREEK	W. SHORE AT BRIDGE
66	" "	HUMBER RIVER	E. SHORE HUMBER DELTA
67	" "	TORONTO HARBOUR	N. SHORE OLYMPIC ISLAND
68	" "	ROUGE RIVER	BEACH W. OF RIVER
69	" "	DUFFINS CREEK	BEACH W. OF RIVER
70	" "	OSHAWA CREEK	BEACH E. OF HARBOUR
71	" "	DARLINGTON PROV. PK.	INLET AT DARLINGTON BAY
72	" "	GANARASKA RIVER	BEACH E. OF HARBOUR
73	" "	GAGES CREEK	BEACH E. & W. OF CREEK
74	" "	COBOURG CREEK	BEACH E. OF CREEK
75	" "	PRESQUILE PROV. PK.	BEACH ON W. SHORELINE
76	" "	OUTLET PROV. PK.	BEACH E. OF OUTLET R.
77	" "	GLENORA	BEACH E. OF MNR RES. STN.
79	" "	CATARAQUI RIVER	CRERAR PARK BAY
78	" "	WOLFE ISLAND	SANDY BEACH BAY
80	ST. LAWRENCE R.	MAITLAND	BLUE CHURCH BAY
81	" "	MACDONNELL ISL	EAST BEACH AREA
82	" "	CORNWALL	INLET BELOW BRIDGE
83	" "	GRASS RIVER (NY)	EAST SHORE DELTA
84	" "	RAQUETTE RIVER (NY)	EAST SHORE DELTA

5204g
dc

Appendix 2: Organochlorine residues in young-of-the-year spottail shiners from the Great Lakes
Values shown are means with SD in ng/g of whole fish analyses.

Site No.	Sampling Site	Year	No. of Samples	Fish Size (mm)	% Fat	PCB	≤DDT	Mirex	≤BHC	≤Chlordane
Lake Superior										
1.	Pine Bay	1983	7	38±3	2.6±1.0	ND	TR	ND	ND	ND
2.	Kam River	1979	8	30±4	2.0±.6	21±14	10±6	ND	ND	4±2
2.	" "	1983	7	37±3	3.2±.7	82±13	10±3	ND	3±1	ND
3.	Misson River	1980	7	46±3	2.0.2	77±15	25±7	ND	1±0	34±9
3.	" "	1983	7	44±3	3.8±.6	139±21	5±3	ND	TR	ND
4.	Black Bay	1983	7	42±3	2.1±.4	ND	3±0	ND	TR	ND
5.	Nipigon Bay	1979	8	32±4	3.5±.4	22±14	21±13	ND	ND	7±4
5.	" "	1983	6	35±3	2.6±.7	51±5	2±1	ND	3±2	ND
6.	Terrace Bay	1983	7	32±5	4.1±1.0	38±8	2±1	ND	2±2	ND
7.	Jackfish Bay	1979	7	33±4	2.0±.4	TR	ND	ND	ND	ND
7.	" "	1983	7	36±2	4.0±.5	89±22	3±1	ND	5±1	ND
8.	Heron Bay	1979	8	35±2	2.5±.7	TR	TR	ND	ND	TR
9.	Peninsula Harbour	X1983	7	32±2	5.2±.6	159±30	TR	ND	5±1	ND
10.	Batchawana Bay	1979	6	35±4	5.2±.4	ND	ND	ND	ND	ND
10.	" "	1983	7	43±6	2.6±.2	ND	6±2	ND	ND	TR
St. Mary's River										
11.	Sault Ste Marie	XX1983	4	67±6	3.2±.4	25±5	10±1	ND	ND	ND
12.	Little Lake George	1979	6	32±6	2.5±.9	TR	5±4	ND	5±3	3±1
Georgian Bay										
13.	Blind River	1979	8	35±5	1.5±1.0	ND	1±2	ND	ND	3±2
13.	" "	1981	5	48±5	1.8±.7	53±10	33±7	ND	6±1	16±4
14.	French River	1979	8	34±3	1.1±.3	ND	ND	ND	ND	ND
15.	Seguin River	1979	7	43±4	1.1±.2	ND	ND	ND	ND	ND
16.	Thunder Beach	1980	7	47±2	3.7±.8	35±32	25±15	ND	5±2	13±4
17.	Nottawasaga River	1977	8	58±1	8.0±.2	90±12	120±33	ND	9±5	17±2
17.	" "	1980	3	52±2	5.2±.1	43±30	36±24	ND	4±2	6±1
18.	Pretty River	1979	8	38±3	1.5±.5	59±9	17±14	ND	ND	ND
19.	Beaver River	1979	8	41±5	1.2±.5	36±5	9±5	ND	ND	ND

Appendix 2: Cont'd ...

Site No.	Sampling Site	Year	No. of Samples	Fish Size (mm)	% Fat	PCB	≤ DDT	Mirex	≤BHC	≤Chlordane
	Lake Huron									
20.	Saugeen River	1980	7	45±5	2.8±3	69±9	19±4	ND	TR	5±3
21.	Maitland River	1980	6	46±5	2.2±1.0	47±28	13±6	ND	1±1	4±4
22.	Ausable River	1979	4	55±6	2.8±.4	121±37	59±21	ND	8±2	10±6
22.	" "	1980	7	52±4	4.4±.4	34±4	12±2	ND	8±2	10±6
23.	Perch Creek	1978	8	54±2	2.6±.3	304±20	71±59	ND	12±4	29±20
23.	" "	1980	7	50±5	3.5±1.0	32±18	8±5	ND	7±3	17±6
	St. Clair River									
24.	Sarnia-3	1983	4	46±7	2.8±.3	146±29	16±4	ND	ND	3±1
25.	Stag Island	XX1979	8	52±3	2.9±.3	TR	2±3	ND	ND	5±4
25.	" "	XX1982	7	58±5	1.9±.4	TR	TR	ND	TR	ND
25.	" "	XX1983	6	60±4	2.6±.4	25±10	ND	ND	ND	ND
26.	South Channel	1982	7	59±7	2.0±.3	71±25	4±3	ND	2±1	11±8
	Lake St. Clair									
27.	Chenal Ecarte	1983	7	57±4	1.5±.1	62±9	10±1	ND	TR	ND
28.	Michell Bay	1978	8	54±3	1.8±.2	94±50	24±15	ND	2±1	7±3
28.	" "	1979	7	55±5	1.0±.2	ND	11±3	ND	2±1	3±1
28.	" "	1982	7	58±5	2.2±.2	33±14	4±4	ND	TR	TR
29.	Thames River	1977	8	59±1	1.5±.3	67±18	17±4	ND	ND	5±3
29.	" "	1979	4	70±5	2.4±.1	23±10	14±3	ND	6±0	12±4
29.	" "	1982	7	62±5	1.8±.2	26±7	2±2	ND	1±1	TR
30.	Pike Creek	1978	8	57±2	2.0±.2	269±55	17±4	ND	ND	10±9
30.	" "	1979	4	63±6	2.1±.5	114±61	46±19	ND	TR	10±4
30.	" "	1980	7	62±6	1.2±.2	67±21	26±3	ND	2±1	7±1
30.	" "	1982	7	61±6	1.7±.2	64±10	19±4	ND	TR	TR
30.	" "	1983	7	52±4	1.9±.3	29±5	10±3	ND	TR	TR

Appendix 2: Cont'd ...

Site No.	Sampling Site	Year	No. of Samples	Fish Size (mm)	% Fat	PCB	∑ DDT	Mirex	∑BHC	∑Chlordane
Detroit River										
31.	Turkey Creek	1983	4	59±5	3.5±1.0	316±172	12±3	ND	4±1	4±1
32.	Grassy Island (Michigan)	1983	5	63±4	2.4±.9	912±195	21±6	ND	5±2	4±2
33.	Fighting Island	1980	6	55±4	2.2±.5	96±24	14±1	ND	4±2	8±2
33.	" "	1983	6	59±3	2.7±1.0	290±59	ND	ND	6±5	4±1
34.	Amherstburg	1982	5	66±3	2.9±.2	304±116	2±1	ND	2±1	9±3
34.	"	1983	7	64±6	2.3±.7	153±65	22±12	ND	4±1	6±2
35.	Celeron Island (Michigan)	1982	5	63±3	3.8±.2	1696±438	14±11	ND	2±1	8±5
35.	" "	1983	6	72±3	2.7±1.0	1709±415	22±7	ND	3±1	12±7
36.	Sturgeon Bar (Michigan)	1982	5	64±4	2.0±.2	2997±570	ND	ND	ND	10±8
Lake Erie										
37.	Big Creek	1977	7	57±3	0.9±.1	438±40	75±15	ND	ND	ND
37.	" "	1978	7	55±2	1.0±.2	510±93	42±22	ND	TR	8±5
37.	" "	1980	7	60±4	1.4±.1	387±95	27±11	ND	TR	6±3
37.	" "	1981	7	59±5	1.7±.3	307±85	31±15	ND	5±1	7±3
37.	" "	1982	7	60±5	1.6±.3	189±69	2±1	ND	ND	ND
38.	Leamington	1975	5	63±3	1.8±.2	844±403	95±22	ND	ND	ND
38.	"	1977	8	58±4	1.6±.3	467±113	141±47	ND	ND	27±8
38.	"	1978	10	55±1	1.7±.3	528±55	47±10	ND	TR	18±5
38.	"	1979	7	61±4	3.4±.5	337±79	26±4	ND	4±1	14±5
38.	"	1980	7	60±4	1.4±.1	150±37	21±4	ND	1±1	8±2
38.	"	1981	7	59±5	1.7±.3	266±38	51±34	ND	4±1	8±1
38.	"	1982	7	60±5	1.6±.1	236±30	44±15	ND	5±2	9±4
38.	"	1983	7	62±5	2.0±.0	260±112	13±4	ND	3±0	3±1
39.	Port Rowan	1975	5	59±4	2.1±.6	59±29	133±66	ND	ND	ND
39.	" "	1979	8	71±5	1.9±.4	30±9	54±19	ND	TR	23±3
40.	Port Stanley	1979	8	44±7	1.4±.7	53±31	16±3	ND	ND	6±2
40.	" "	1983	4	60±8	2.5±.3	232±30	23±15	ND	1±1	ND
41.	Centre Creek	1979	5	56±4	3.1±.1	47±22	24±5	ND	4±1	5±2
41.	" "	1982	7	54±5	2.4±.2	54±30	6±6	ND	TR	10±4
41.	" "	1983	7	61±5	2.2±.3	49±9	22±10	ND	TR	TR

Appendix 2: Cont'd ...

Site No.	Sampling Site	Year	No. of Samples	Fish Size (mm)	% Fat	PCB	≤DDT	Mirex	≤BHC	≤Chlordane
42.	Nanticoke Creek	1979	5	57±5	1.8±.1	50±8	31±8	ND	ND	7±3
42.	" "	1981	3	56±4	2.8±.6	36±32	16±6	ND	3±1	3±2
42.	" "	1982	6	52±8	2.6±.5	30±8	9±6	ND	2±1	4±2
43.	Grand River	1976	8	46±2	2.6±.3	146±12	42±11	ND	10±3	10±4
43.	" "	1977	9	45±3	1.5±.2	56±12	16±2	ND	ND	ND
43.	" "	1979	8	56±7	2.0±.5	90±40	24±5	ND	7±5	4±2
43.	" "	1982	6	53±4	1.8±.4	48±6	5±4	ND	1±1	2±2
44.	Port Colborne	1975	5	55±3	1.2±.3	82±29	32±23	ND	ND	ND
45.	Thunder Bay	1978	8	51±2	3.0±.7	157±28	38±12	ND	5±1	7±3
45.	" "	1979	5	54±7	1.9±.3	31±12	14±5	ND	ND	9±2
45.	" "	1980	7	54±7	1.9±.7	95±29	29±12	ND	3±1	20±9
45.	" "	1982	7	53±6	1.3±.4	60±17	19±8	ND	ND	ND
45.	" "	1983	7	59±4	1.9±.5	31±6	TR	ND	TR	3±1
Niagara River										
46.	Fort Erie	1982	6	53±2	2.6±.2	181±69	31±12	ND	4±1	6±4
46.	" "	1983	7	61±5	2.4±.3	66±20	15±6	ND	TR	ND
47.	Frenchman's Creek	1980	5	53±2	1.7±.4	66±31	13±9	ND	3±1	9±3
47.	" "	1981	5	49±3	1.6±.2	164±56	37±19	ND	1±1	TR
47.	" "	1982	7	56±3	3.7±.5	216±34	57±10	ND	6±1	8±6
47.	" "	1983	5	56±5	2.2±.2	64±21	24±6	ND	ND	3±1
48.	Strawberry Island (N.Y.)	1983	6	66±3	3.5±.3	60±28	23±5	ND	4±2	4±1
49.	Wheatfield (N.Y.)	1983	6	62±3	2.9±.9	276±160	28±8	ND	5±1	6±2
50.	102nd Street (N.Y.)	1980	7	54±4	2.2±.5	389±108	18±11	5±4	33±17	10±3
50.	" " "	1981	7	49±3	1.4±.2	327±53	9±4	17±6	31±11	11±3
50.	" " "	1982	6	51±3	1.5±.2	512±143	18±6	ND	28±11	15±6
51.	Cayuga Creek (N.Y.)	1981	4	51±4	2.3±.3	573±84	23±4	18±4	34±9	18±4
51.	" "	1982	6	52±2	2.7±.8	880±136	50±4	6±2	29±10	19±7
51.	" "	1983	5	55±5	3.0±.2	406±194	29±15	9±15	14±19	5±4
52.	Search & Rescue Station(NY)	1982	5	52±3	3.0±.5	1091±351	14±7	5±3	7±3	13±6
52.	" " " "	1983	6	59±5	3.0±.5	867±153	TR	ND	TR	5±1
53.	Usher's Creek	1982	7	56±3	3.8±.5	124±14	30±5	ND	ND	10±2
53.	" "	1983	7	60±5	2.8±.4	67±17	24±4	ND	ND	TR

Appendix 2: Cont'd ...

Site No.	Sampling Site	Year	No. of Samples	Fish Size (mm)	% Fat	PCB	≤DDT	Mirex	≤BHC	≤Chlordane
54.	East Welland River	1980	5	50±4	2.3±.6	56±14	4±3	ND	1±1	5±2
54.	" " "	1982	5	52±2	2.2±.4	96±5	36±12	ND	TR	7±3
54.	" " "	1983	5	61±3	4.0±.7	49±22	18±6	ND	4±1	TR
55.	West Welland River	1982	5	51±3	2.3±.3	187±45	19±15	ND	TR	10±5
56.	Queenston	1979	8	49±3	2.2±.4	108±28	34±9	ND	4±4	21±6
Niagara River - Cont'd										
56.	Queenston	1980	7	53±2	3.3±.3	134±20	11±6	TR	7±2	21±19
56.	"	1981	6	49±2	1.2±.4	329±120	107±57	15±8	4±3	47±20
56.	"	1982	5	50±2	1.8±.4	245±21	61±19	7±6	3±1	8±2
57.	Lewiston (N.Y.)	1981	5	50±3	1.4±.2	405±87	74±17	12±3	ND	9±3
57.	"	1982	5	50±3	2.1±.3	180±63	26±10	6±4	ND	8±2
58.	Peggy's Eddy (N.Y.)	1980	7	58±4	2.8±.5	233±58	36±17	9±6	15±7	14±6
58.	" "	1981	7	53±4	2.0±.4	309±90	189±62	6±3	TR	10±14
58.	" "	1982	6	51±3	2.5±.5	260±56	47±22	6±2	3±1	7±3
59.	Niagara-on-the-Lake	1975	5	56±4	2.3±.3	690±195	244±52	NA	ND	ND
59.	" " " "	1977	7	51±3	2.5±.6	654±170	157±38	13±4	50±19	61±19
59.	" " " "	1978	8	51±1	1.9±.2	320±49	99±49	29±8	7±2	6±10
59.	" " " "	1979	8	50±2	2.4±.4	153±23	26±9	TR	ND	21±18
59.	" " " "	1980	7	56±2	2.1±.4	266±51	41±9	11±2	26±7	24±6
59.	" " " "	1981	7	55±3	1.9±.1	327±62	73±15	10±3	ND	11±4
59.	" " " "	1982	5	53±3	2.2±.4	255±24	82±14	6±2	4±1	17±7
59.	" " " "	1983	6	59±5	2.5±.5	136±55	TR	ND	ND	3±1
Lake Ontario										
60.	Welland Canal	1982	7	48±6	2.0±.4	158±42	NA	6±3	NA	NA
60.	" "	1983	7	63±3	2.7±.2	229±54	38±13	TR	ND	44±12
61.	Twelve Mile Creek	1975	5	58±5	5.2±.9	890±319	98±46	NA	ND	ND
61.	" " "	1978	8	51±3	2.9±.4	349±63	88±17	20±12	7±2	26±10
61.	" " "	1979	8	51±4	2.1±.4	271±49	66±19	ND	3±1	ND
61.	" " "	1980	7	48±6	1.9±.3	148±28	50±10	TR	3±1	7±2
61.	" " "	1981	6	54±5	2.5±.5	205±15	93±32	TR	5±1	6±2
61.	" " "	1982	7	41±5	1.6±.3	279±26	33±22	21±5	TR	8±4

Appendix 2: Cont'd ...

Site No.	Sampling Site	Year	No. of Samples	Fish Size (mm)	% Fat	PCB	∑DDT	Mirex	∑BHC	∑Chlordane
61.	" " "	1983	7	64±3	3.2±.4	236±47	48±6	8±4	ND	4±2
62.	Burlington Beach	1977	9	55±4	5.3±.7	833±106	267±36	9±2	11±4	47±16
62.	" "	1980	7	47±6	2.7±.2	250±54	46±11	TR	4±1	14±4
62.	" "	1983	7	57±4	4.5±.7	375±68	40±12	7±2	TR	4±2
63.	Bronte Creek	1979	8	53±3	3.5±.5	188±48	35±6	ND	3±2	19±3
64.	Credit River	1976	10	62±3	2.8±.5	1315±578	278±106	32±13	20±9	50±22
64.	" "	1978	8	60±3	2.6±.3	590±53	96±12	28±3	TR	37±8
64.	" "	1979	8	56±3	3.7±.6	186±28	70±12	ND	8±3	36±6
64.	" "	1980	7	62±4	2.7±.6	238±59	59±20	TR	5±3	24±5
64.	" "	1982	7	52±7	3.2±.2	183±27	66±32	7±2	3±0	21±7
64.	" "	1983	7	60±8	4.1±1.5	329±46	23±11	5±2	ND	5±2
65.	Mimico Creek	1981	5	68±4	6.4±.2	1051±105	135±19	ND	19±2	47±3
65.	" "	1982	6	66±7	5.0±.3	572±45	52±7	TR	5±2	17±3
65.	" "	1983	7	70±4	5.4±.4	542±80	41±4	ND	6±2	25±3
66.	Humber River	1977	8	62±3	7.3±.4	2218±263	268±32	5±2	41±8	58±16
66.	" "	1978	8	58±5	5.8±.5	2938±391	406±99	15±4	3±4	ND
66.	" "	1979	8	60±6	4.0±1.3	1223±347	76±12	ND	4±1	47±9
66.	" "	1980	6	62±5	4.0±.4	621±66	41±4	ND	15±5	36±6
66.	" "	1981	6	62±5	5.0±.8	954±45	86±41	ND	9±3	26±9
66.	" "	1982	6	58±2	3.7±.4	353±70	28±20	ND	3±0	22±1
66.	" "	1983	7	68±3	5.2±.4	537±122	48±7	ND	5±1	21±2
67.	Toronto Harbour	1979	8	46±3	5.1±1.0	423±105	82±17	TR	15±3	16±2
68.	Rouge River	1979	5	45±4	3.2±.2	82±35	26±13	ND	6±2	TR
69.	Duffins Creek	1980	7	61±3	2.8±.3	111±20	42±8	ND	5±1	10±5
70.	Oshawa Creek	1982	4	56±11	5.8±.9	227±40	27±6	9±4	6±1	19±4
71.	Darlington Provincial Park	1975	5	58±4	4.9±.8	420±116	94±29	NA	ND	ND
71.	" " "	1976	10	60±3	5.1±.7	360±79	75±9	6±2	6±1	19±7
72.	Ganaraska River	1980	7	57±9	4.5±.7	1202±449	170±38	6±5	11±13	13±9
73.	Gages Creek	1979	3	49±3	6.0±.1	197±12	47±19	6±1	10±1	20±2
74.	Cobourg Creek	1978	8	49±5	5.0±1.0	270±53	77±22	19±4	9±4	26±8
75.	Presqu'ile Provincial Park	1975	6	54±4	2.5±.4	505±89	82±12	NA	ND	TR

Appendix 2: Cont'd ...

Site No.	Sampling Site	Year	No. of Samples	Fish Size (mm)	% Fat	PCB	≤DDT	Mirex	≤BHC	≤Chlordane
75.	" " "	1979	8	49±3	3.4±.7	122±22	37±10	ND	ND	8±5
76.	Outlet River	1979	8	53±3	4.3±1.2	112±32	58±10	10±3	14±6	37±7
76.	" "	1980	7	53±4	4.8±.4	185±48	52±9	8±2	8±1	22±3
76.	" "	1982	7	49±1	4.8±.3	128±17	7±2	7±2	4±2	12±5
77.	Glenora	1975	5	58±4	2.9±.3	111±27	41±7	NA	ND	ND
78.	Wolfe Island	1982	6	54±2	3.9±.4	121±48	33±8	8±3	5±1	ND
78.	" "	1983	7	65±4	2.9±.4	81±15	16±5	7±1	ND	TR
79.	Cataragui River	1980	7	59±3	3.2±.3	99±10	17±2	ND	3±0	5±2
St. Lawrence River										
80.	Maitland	1983	5	56±4	2.0±.5	148±73	22±6	ND	ND	ND
81.	MacDonnell Island	1979	8	49±5	1.4±.6	ND	79±20	ND	ND	9±2
82.	Cornwall	1979	3	50±3	3.6±1.2	243±31	62±14	7±1	7±3	8±4
82.	Cornwall	1980	4	55±3	4.1±.8	367±100	50±10	12±2	4±5	5±7
82.	"	1981	4	52±3	2.0±.0	234±34	22±8	8±2	3±1	5±2
82.	"	1983	5	51±4	2.8±.3	199±71	25±12	8±5	ND	2±1
83.	Grass River (N.Y.)	1979	7	51±2	1.9±.4	2072±187	95±14	TR	4±1	18±10
83.	" "	1981	7	53±2	1.7±.3	1117±235	39±13	8±5	TR	4±2
83.	" "	1983	6	52±4	1.6±.2	954±343	6±4	6±2	ND	ND
84.	Raguette River (N.Y.)	1979	7	50±2	2.1±.5	377±81	92±25	6±4	6±2	21±9
Detection Limits						20	1	5	1	2

TR - Trace
ND - Not Detected
NA - Not Analyzed
X - Emerald Shiners
XX - Yellow Perch

Appendix 3: Mercury residues in young-of-the-year spottail shiners from the Great Lakes. Values shown are means with S.D. of whole fish analyses

Site No.	Sampling Site	Year	No. of Samples	Mercury ng/g
2.	Thunder Bay - Lake Superior	1980	7	30±6
16.	Thunder Beach - Georgian Bay	1980	7	14±8
17.	Nottawasaga River - Georgian Bay	1982	7	29±4
20.	Saugeen River - Lake Huron	1980	7	30±10
21.	Maitland River " "	1980	6	50±13
22.	Ausable River " "	1980	7	20±6
23.	Perch Creek " "	1980	7	21±7
26.	Main Channel - Lake St. Clair	1982	7	81±7
28.	Mitchell Bay " "	1978	8	70±10
28.	" " "	1979	7	80±20
28.	" " "	1982	7	56±5
29.	Thames River " "	1977	8	62±6
29.	" " " "	1979	4	50±16
29.	" " " "	1982	7	31±4
30.	Pike Creek " "	1978	8	50±8
30.	" " " "	1979	4	38±10
30.	" " " "	1980	7	41±9
30.	" " " "	1982	7	46±8
34.	Amherstburg - Detroit River	1982	5	52±11
35.	Celeron Island " "	1982	5	18±8
36.	Sturgeon Bar " "	1982	5	18±4
37.	Big Creek - Lake Erie	1977	7	93±16
37.	" " " "	1978	7	40±7
37.	" " " "	1980	7	47±26
37.	" " " "	1982	7	61±7
38.	Point Pelee " "	1977	8	56±7
38.	" " " "	1978	8	50±5
38.	" " " "	1979	7	16±5
38.	" " " "	1980	7	12±4
38.	" " " "	1982	7	29±4
39.	Port Stanley " "	1979	8	11±4
40.	Port Rowan " "	1979	8	TR
42.	Nanticoke Creek "	1979	5	22±8
42.	" " "	1982	8	25±5
43.	Grand River " "	1976	8	54±10
43.	" " " "	1977	9	37±18
43.	" " " "	1979	8	21±4
43.	" " " "	1982	6	22±4
45.	Thunder Bay " "	1978	8	40±5
45.	" " " "	1979	5	30±10
45.	" " " "	1982	7	49±7
46.	Fort Erie - Niagara River	1982	6	47±10
47.	Frenchman's Creek - Niagara River	1982	7	36±5
50.	102nd Street " "	1980	6	58±23
50.	" " " "	1982	6	123±16
51.	Cayuga Creek " "	1982	6	52±8
52.	Search & Rescue Stn. " "	1982	5	42±4
53.	Usher's Creek " "	1982	7	37±5

Appendix 3: Mercury residues in young-of-the-year spottail shiners from the Great Lakes. Values shown are means with S.D. of whole fish analyses

Site No:	Sampling Site	Year	No. of Samples	Mercury ng/g
56.	Queenston - Niagara River	1979	8	30±6
56.	" " "	1980	7	14±5
56.	" " "	1982	5	38±4
57.	Lewiston " "	1982	5	38±4
58.	Peggy's Eddy " "	1982	6	35±5
59.	Niagara-on-the-Lake - Niagara River	1977	7	77±13
59.	" " " " " "	1978	8	50±8
59.	" " " " " "	1979	8	50±12
59.	" " " " " "	1980	7	23±5
59.	" " " " " "	1982	5	43±13
60.	Welland Canal - Lake Ontario	1982	7	54±5
61.	Twelve Mile Creek " "	1982	7	29±4
62.	Burlington Beach " "	1977	9	39±9
62.	" " " "	1980	7	16±5
63.	Bronte Creek " "	1979	8	20±4
64.	Credit River " "	1978	8	39±6
64.	" " " "	1979	8	24±10
64.	" " " "	1980	7	33±5
64.	" " " "	1982	7	39±4
65.	Mimico Creek " "	1982	6	30±0
66.	Humber River " "	1977	10	44±5
66.	" " " "	1978	9	36±7
66.	" " " "	1979	8	30±19
66.	" " " "	1980	6	22±4
67.	Toronto Harbour " "	1979	8	26±5
68.	Rouge River " "	1979	5	22±8
69.	Duffins Creek " "	1980	7	24±8
70.	Oshawa Creek " "	1982	4	15±6
71.	Darlington Prov. Pk. "	1976	10	23±13
73.	Gages Creek " "	1980	4	43±5
74.	Cobourg Creek " "	1978	8	44±5
75.	Presqu'ile Point " "	1979	8	39±4
76.	Outlet River " "	1979	8	30±9
76.	" " " "	1980	3	13±6
76.	" " " "	1982	7	30±6
79.	Wolfe Island " "	1982	6	32±4
81.	MacDonnel Island - St. Lawrence	1979	8	56±5
82.	Cornwall " "	1979	3	70±10
82.	" " "	1980	4	68±10
83.	Grass River " "	1979	7	43±12
84.	Raquette River " "	1979	7	39±7
	Detection Limit			10

TR - Trace

3599g

Appendix 4: Chlorinated Aromatic Residues in Young-of-the-Year Spottail Shiners from the Great Lakes. Values are means with SD in ng/g of Whole Fish Analysis

Site No.	Sampling Site	Year	No. of Samples	Fish Size (mm)	% Fat	Chlorinated Benzenes TRI	TETRA	PENTA	HEXA	Hexachloro -ethane	Hexachloro -butadiene	Octachloro -styrene	Trichloro -toluene
Lake Superior													
1.	Pine Bay	1983	3	38±3	2.6 ±1.0	ND	ND	ND	ND	ND	ND	ND	ND
2.	Kam River	1983	3	30±4	2.0±.6	ND	ND	ND	ND	ND	ND	ND	ND
3.	Mission River	1983	3	46±3	2.0±.2	ND	ND	ND	ND	ND	ND	ND	ND
4.	Black Bay	1983	3	42±3	2.1±.4	ND	ND	ND	ND	ND	ND	ND	ND
5.	Nipigon Bay	1983	3	32±4	3.5±.4	ND	ND	ND	ND	ND	ND	ND	ND
6.	Terrace Bay	1983	3	32±5	4.1±1.0	ND	ND	ND	ND	ND	ND	ND	ND
7.	Jackfish Bay	1983	3	33±4	2.0±.4	ND	ND	ND	ND	ND	ND	ND	ND
8.	Peninsula Harbour	1983	3	32±2	5.2±.6	ND	ND	ND	ND	ND	ND	ND	ND
St. Mary's River													
11.	Sault Ste. Marie	1983	3	67±6	3.2±.4	ND	ND	ND	ND	ND	ND	ND	ND
St. Clair River													
24.	Sarnia-3	1983	3	46±7	2.8±.3	ND	ND	ND	231±26	ND	ND	560±148	ND
25.	Stag Island	1982	7	58±5	1.9±.4	NA	NA	NA	1±2	NA	NA	37±29	NA
25.	Stag Island	1983	6	60±4	2.6±.4	ND	ND	ND	7±7	ND	ND	59±39	ND
26.	South Channel	1982	7	59±7	2.0±.3	ND	7±5	ND	13±7	4±2	5±4	95±10	ND
Lake St. Clair													
27.	Chenal Ecarte	1983	7	57±4	1.5±.1	ND	ND	ND	10±3	ND	2±1	28±8	ND
28.	Michell Bay	1979	2	55±5	1.0±.2	5	3	3	8	ND	ND	30	ND
28.	Michell Bay	1982	2	58±4	2.2±.2	ND	ND	ND	1	6	3	2	ND
30.	Pike Creek	1983	7	52±4	1.9±.3	NA	NA	NA	ND	NA	NA	3±1	NA
Detroit River													
31.	Turkey Creek	1983	4	59±5	3.5±1.0	ND	ND	ND	4±4	ND	ND	10±2	ND
32.	Grassy Island	1983	5	63±4	2.4±.9	ND	ND	ND	4±1	ND	ND	2±1	ND
33.	Fighting Island	1983	6	59±3	2.7±1.0	ND	ND	ND	4±1	ND	ND	9±1	ND
34.	Amherstburg	1983	7	64±6	2.3±.7	NA	NA	NA	5±2	NA	NA	8±2	NA

Site No.	Sampling Site	Year	No. of Samples	Fish Size (mm)	% Fat	Chlorinated Benzenes TRI	TETRA	PENTA	HEXA	Hexachloro -ethane	Hexachloro -butadiene	Octachloro -styrene	Trichloro -toluene
35.	Celeron Island	1982	5	63±3	3.8±.2	NA	NA	NA	8±1	NA	NA	6±0	NA
35.	Celeron Island	1983	6	72±3	2.7±1.0	NA	NA	NA	2±2	NA	NA	4±1	NA
36.	Sturgeon Bar	1982	3	64±4	2.0±.2	3±0	ND	2±1	5±3	ND	ND	6±1	ND
Lake Erie													
37.	Big Creek	1980	3	66±5	1.1±.2	ND	ND	ND	ND	ND	ND	ND	ND
37.	Big Creek	1981	3	60±4	2.1±.3	ND	ND	ND	3±2	ND	ND	ND	ND
37.	Big Creek	1982	7	60±5	1.6±.3	NA	NA	NA	3±1	NA	NA	5±1	NA
38.	Leamington	1979	2	61±4	3.4±.5	TR	4	6	5	ND	ND	4	ND
38.	Leamington	1982	7	60±5	1.6±.1	NA	NA	NA	2±3	NA	NA	3±1	NA
38.	Leamington	1983	7	62±5	2.0±.0	NA	NA	NA	1±0	NA	NA	ND	NA
40.	Port Stanley	1983	4	60±8	2.5±.3	ND	ND	TR	ND	ND	ND	ND	ND
41.	Centre Creek	1979	3	56±4	3.1±.1	ND	TR	3±2	TR	ND	ND	TR	ND
41.	Centre Creek	1981	3	54±5	2.5±.3	2±2	ND	ND	TR	ND	ND	ND	ND
41.	Centre Creek	1982	7	54±5	2.4±.2	NA	NA	NA	TR	NA	NA	2±3	NA
41.	Centre Creek	1983	3	61±5	2.2±.3	ND	ND	10±4	ND	ND	ND	ND	ND
42.	Nanticoke Creek	1979	3	57±5	1.8±.1	ND	ND	TR	TR	ND	ND	TR	ND
42.	Nanticoke Creek	1982	6	52±8	2.6±.5	NA	NA	NA	ND	NA	NA	ND	NA
43.	Grand River	1982	6	53±4	1.8±.4	NA	NA	NA	ND	NA	NA	ND	NA
45.	Thunder Bay	1980	3	54±7	1.9±.7	ND	ND	5±6	ND	ND	ND	ND	ND
45.	Thunder Bay	1982	3	53±6	1.3±.4	ND	ND	ND	TR	ND	ND	ND	ND
45.	Thunder Bay	1983	3	59±4	1.9±.5	ND	ND	ND	ND	ND	ND	ND	ND
Niagara River													
46.	Fort Erie	1982	3	53±2	2.6±.2	ND	TR	ND	TR	ND	ND	ND	ND
46.	Fort Erie	1983	3	61±5	2.4±.3	ND	ND	ND	ND	ND	ND	ND	ND
47.	Frenchman's Creek	1982	7	56±3	3.7±.5	NA	NA	NA	1±0	NA	NA	ND	NA
47.	Frenchman's Creek	1983	5	56±5	2.2±.2	NA	NA	NA	NA	NA	NA	NA	NA

Site No.	Sampling Site	Year	No. of Samples	Fish Size (mm)	% Fat	Chlorinated Benzenes				Hexachloro -ethane	Hexachloro -butadiene	Octachloro -styrene	Trichloro -toluene
						TRI	TETRA	PENTA	HEXA				
48.	Strawberry Island	1983	3	66±3	3.5±.3	ND	ND	ND	ND	ND	ND	ND	ND
49.	Wheatfield	1983	3	62±3	2.9±.9	ND	ND	2±0	3±2	ND	ND	ND	ND
50.	102nd Street	1982	6	51±3	1.5±.2	NA	NA	NA	8±3	NA	NA	ND	NA
51.	Cayuga Creek	1982	6	52±2	2.7±.8	NA	NA	NA	12±2	NA	NA	ND	NA
51.	Cayuga Creek	1983	3	55±5	3.0±.2	17±15	84±66	91±26	5±5	ND	3±1	ND	22±11
52.	Search & Rescue	1982	3	52±3	3.0±5	ND	TR	ND	8±4	ND	7±3	6±3	ND
52.	Search & Rescue	1983	6	59±5	3.0±.5	TR	6±1	5±1	2±2	ND	ND	3±1	35±35
53.	Ushers' Creek	1982	3	56±3	3.8±.5	25±6	ND	ND	1±0	ND	ND	ND	ND
53.	Ushers' Creek	1983	3	60±5	2.8±.4	ND	ND	ND	TR	ND	ND	ND	ND
54.	East Welland R.	1982	5	52±2	2.2±.4	NA	NA	NA	1±1	NA	NA	ND	NA
54.	East Welland R.	1983	5	61±3	4.0±.7	NA	NA	NA	ND	NA	NA	ND	NA
55.	West Welland R.	1982	3	51±3	2.3±.3	50±1	ND	ND	1±0	ND	TR	TR	ND
56.	Queenston	1982	5	50±2	1.8±.4	NA	NA	NA	3±0	NA	NA	2±1	NA
57.	Lewiston	1981	3	50±3	1.4±.2	4±5	5±2	7±2	7±0	ND	ND	3±1	NA
58.	Peggy's Eddy	1980	3	58±4	2.8±.5	5±7	31±9	21±4	14±2	ND	ND	6±2	ND
58.	Peggy's Eddy	1981	3	53±4	2.0±.4	4±5	5±1	5±1	6±1	ND	ND	3±1	ND
58.	Peggy's Eddy	1982	3	51±3	2.5±.5	ND	3±4	ND	3±1	4±4	ND	2±1	ND
59.	Niagara-on-the-Lake	1979	2	50±2	2.4±.4	4	115	TR	12	ND	TR	3	ND
59.	Niagara-on-the-Lake	1980	3	56±2	2.1±.4	ND	3±4	12±6	9±3	ND	ND	9±1	ND
59.	Niagara-on-the-Lake	1981	3	55±3	1.9±.1	ND	4±1	7±7	5±2	ND	ND	3±0	ND
59.	Niagara-on-the-Lake	1982	5	53±3	2.2±.4	2±1	ND	ND	4±1	ND	2±2	4±1	ND
59.	Niagara-on-the-Lake	1983	3	59±5	2.5±.5	ND	ND	3±3	3±3	ND	ND	2±1	ND
Lake Ontario													
60.	Welland Canal	1982	3	48±6	2.0±.4	ND	2±1	ND	ND	2±1	2±1	3±1	ND
60.	Welland Canal	1983	3	63±3	2.7±.2	ND	ND	ND	3±1	ND	ND	3±1	ND

Site No.	Sampling Site	Year	No. of Samples	Fish Size (mm)	% Fat	Chlorinated Benzenes TRI	TETRA	PENTA	HEXA	Hexachloro -ethane	Hexachloro -butadiene	Octachloro -styrene	Trichloro -toluene
61.	Twelve Mile Ck.	1979	2	51±4	2.1±.4	ND	79	ND	TR	ND	ND	TR	ND
61.	Twelve Mile Ck.	1981	2	54±5	2.5±.5	ND	ND	ND	1	ND	ND	2	ND
61.	Twelve Mile Ck.	1982	3	41±5	1.6±.3	ND	ND	ND	TR	ND	ND	5±1	ND
61.	Twelve Mile Ck.	1983	3	64±3	3.2±.4	ND	ND	ND	5±2	ND	ND	5±2	ND
62.	Burlington Beach	1983	3	57±4	4.5±.7	ND	ND	ND	2±1	ND	ND	1±0	ND
64.	Credit River	1979	2	56±3	3.7±.6	ND	3	3	5	ND	ND	TR	ND
64.	Credit River	1982	7	52±7	3.2±.2	NA	NA	NA	2±1	NA	NA	1±0	NA
64.	Credit River	1983	7	60±8	4.1±1.5	NA	NA	NA	2±0	NA	NA	1±0	NA
65.	Mimico Creek	1981	3	68±4	6.4±.2	ND	ND	4±1	7±0	ND	ND	3±2	NA
65.	Mimico Creek	1982	3	68±7	5.0±.3	4±2	TR	ND	4±1	3±2	NA	TR	NA
65.	Mimico Creek	1983	3	70±4	5.4±.4	ND	3±3	18±5	13±1	ND	ND	ND	ND
66.	Humber River	1979	2	60±6	4.0±1.3	2	24	ND	3	ND	ND	2	ND
66.	Humber River	1982	3	58±2	3.7±.4	4±4	5±3	ND	3±1	ND	ND	ND	ND
66.	Humber River	1983	3	68±3	5.2±.4	ND	2±3	6±8	13±3	ND	ND	ND	ND
70.	Oshawa Creek	1982	3	56±11	5.8±.9	ND	TR	ND	2±0	ND	TR	6±5	ND
75.	Presquile Prov. Pk	1979	2	49±3	3.4±.7	7	4	ND	3	ND	ND	TR	ND
76.	Outlet River	1979	2	53±3	4.3±1.2	7	30	ND	2	ND	TR	TR	ND
76.	Outlet River	1980	3	53±4	4.8±.4	ND	ND	ND	ND	ND	ND	ND	ND
76.	Outlet River	1982	2	49±1	4.8±.3	ND	ND	ND	TR	ND	3	TR	ND
78.	Wolfe Island	1982	6	54±2	3.9±.4	NA	NA	NA	1±0	NA	NA	2±1	NA
78.	Wolfe Island	1983	3	65±4	2.9±.4	ND	ND	ND	TR	ND	ND	XTR	ND
80.	Maitland	1983	3	56±4	2.0±.5	ND	ND	ND	2±1	ND	ND	1±0	ND
82.	Cornwall	1983	3	51±4	2.8±.3	ND	ND	ND	2±1	ND	ND	2±0	ND
83.	Grass River	1983	3	52±4	1.6±.2	ND	ND	ND	ND	ND	ND	2±2	ND
DETECTION LIMIT						2	0.5	1	1	1	1	1	1

TR - Trace
ND - Not Detected
NA - Not analyzed

Appendix 5: Chlorinated phenol residues in young-of-the-year spottail shiners from the Great Lakes. Values are means with SD in ng/g of whole fish analyses.

Site No.	Sampling Site	Year	No. of Samples	Fish Size (mm)	% Fat	Trichloro -phenols	Tetrachloro -phenols	Pentachloro -phenols
	Lake Superior							
1.	Pine Bay	1983	3	38±3	2.6±1.0	ND	ND	ND
2.	Kam River	1983	3	30±4	2.0±.6	ND	ND	ND
3.	Mission River	1983	3	46±3	2.0±.2	ND	ND	ND
4.	Black Bay	1983	3	42±3	2.1±.4	ND	ND	ND
5.	Nipigon Bay	1983	3	32±4	3.5±.4	ND	ND	ND
6.	Terrace Bay	1983	3	32±5	4.1±1.0	ND	ND	ND
7.	Jackfish Bay	1983	3	33±4	2.0±.4	ND	ND	ND
9.	Peninsula Harbour	1983	3	32±2	5.2±.6	ND	ND	ND
	St. Mary's River							
11.	Sault Ste. Marie	1983	3	67±6	3.2±.4	ND	ND	ND
	St. Clair River							
26.	South Channel	1982	3	59±7	2.0±.3	ND	ND	ND
	Lake St. Clair							
28.	Mitchell Bay	1979	2	55±5	1.0±.2	ND	ND	ND
28.	Mitchell Bay	1982	3	58±4	2.2±.2	ND	ND	ND
30.	Pike Creek	1982	3	61±6	1.7±.2	ND	ND	ND
	Detroit River							
34.	Amherstburg	1982	3	66±3	2.9±.2	ND	ND	ND
35.	Celeron Island	1982	3	63±3	3.8±.2	ND	ND	ND
36.	Sturgeon Bar	1982	3	64±4	2.0±.2	ND	ND	ND
	Lake Erie							
38.	Leamington	1979	3	61±4	3.4±.5	ND	ND	ND
41.	Centre Creek	1979	3	56±4	3.1±.1	ND	ND	ND
41.	Centre Creek	1981	3	54±5	2.5±.3	ND	ND	63±15
41.	Centre Creek	1982	3	54±5	2.4±.2	ND	ND	ND
41.	Centre Creek	1983	3	61±5	2.2±.3	ND	ND	ND
42.	Nanticoke Creek	1979	3	57±5	1.8±.1	ND	ND	ND
45.	Thunder Bay	1980	3	54±7	1.9±.7	ND	ND	ND
45.	Thunder Bay	1982	3	53±6	1.3±.4	ND	ND	ND

Appendix 5: Continued

Site No.	Sampling Site	Year	No. of Samples	Fish Size (mm)	% Fat	Trichloro -phenols	Tetrachloro -phenols	Pentachloro -phenols
	Niagara River							
46.	Fort Erie	1982	3	53±2	2.6±.2	ND	ND	ND
50.	102nd Street	1982	3	51±3	1.5±.2	ND	ND	70±35
51.	Cayuga Creek	1982	3	52±2	2.7±.8	ND	ND	ND
52.	Search & Rescue Stn.	1982	3	52±3	3.0±.5	ND	ND	ND
53.	Usher's Creek	1982	3	56±3	3.8±.5	ND	ND	ND
54.	East Welland R.	1982	3	52±2	2.2±.4	ND	ND	ND
55.	West Welland R.	1982	3	51±3	2.3±.3	ND	ND	ND
56.	Queenston	1982	3	50±2	1.8±.4	ND	ND	ND
57.	Lewiston	1981	3	50±3	1.4±.2	ND	ND	65±35
57.	Lewiston	1982	3	50±3	2.1±.3	ND	ND	ND
58.	Peggy's Eddy	1980	3	58±4	2.8±.5	ND	ND	ND
58.	" "	1981	3	53±4	2.0±.4	ND	ND	ND
58.	" "	1982	3	51±3	2.5±.5	ND	ND	ND
59.	Niagara-on-the-Lake	1979	2	50±2	2.4±.4	ND	ND	ND
59.	" " " "	1980	3	56±2	2.1±.4	ND	ND	ND
59.	" " " "	1981	3	55±3	1.9±.1	ND	ND	ND
59.	" " " "	1982	3	53±3	2.2±.4	ND	ND	ND
	Lake Ontario							
60.	Welland Canal	1982	3	48±6	2.0±.4	ND	ND	ND
61.	Twelve Mile Creek	1979	2	51±4	2.1±.4	ND	ND	ND
61.	" " "	1981	2	54±5	2.5±.5	ND	ND	ND
61.	" " "	1982	3	41±5	1.6±.3	ND	ND	ND
62.	Burlington Beach	1983	3	57±4	4.5±.7	ND	ND	ND
64.	Credit River	1979	2	56±3	3.7±.6	ND	ND	ND
65.	Mimico Creek	1981	3	68±4	6.4±.2	ND	123±21	1467±153
65.	" "	1982	3	66±7	5.0±.3	ND	ND	213±12
65.	" "	1983	3	70±4	5.4±.4	ND	ND	ND
66.	Humber River	1979	2	60±6	4.0±1.3	ND	ND	ND
66.	" "	1982	3	62±5	4.0±.4	ND	ND	ND
70.	Oshawa Creek	1982	3	56±11	5.8±.9	ND	ND	ND
75.	Presqu'ile Park	1979	2	49±3	3.4±.7	ND	ND	ND
76.	Outlet River	1979	2	53±3	4.3±1.2	ND	ND	ND
76.	" "	1980	3	53±4	4.8±.4	ND	ND	ND
	Detection Limits					50	50	50

ND - Not Detected

TD
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